Manually Initiated Fast Load Control

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This presentation describes the load reduction programs of the Potomac Electric Power Company (Pepco) with results from the week of August 6-9, 2001. Pepco serves the District of Columbia and suburban areas of Maryland. It set a new peak load of 6140 MW on August 9, 2001.

Pepco's load is almost entirely made up of commercial (including governmental) and residential customers. In the 1980's Pepco began two load reduction programs aimed at these customers. The program marketed to commercial customers involves direct communication with the customer through company installed equipment, with short-term feedback of actual meter information during curtailments. The system marketed to residential customers consists of a radio controlled switch on air conditioners and a central control program to force a diversification of load control for those customers who choose the cycling program over the full reduction program. Of those programs, only the radio controlled switch program is described here. Additionally, during emergency conditions, Pepco operates its voltage reduction program through a system of EMS controlled transformer taps with additional controls on certain distribution feeder equipment.

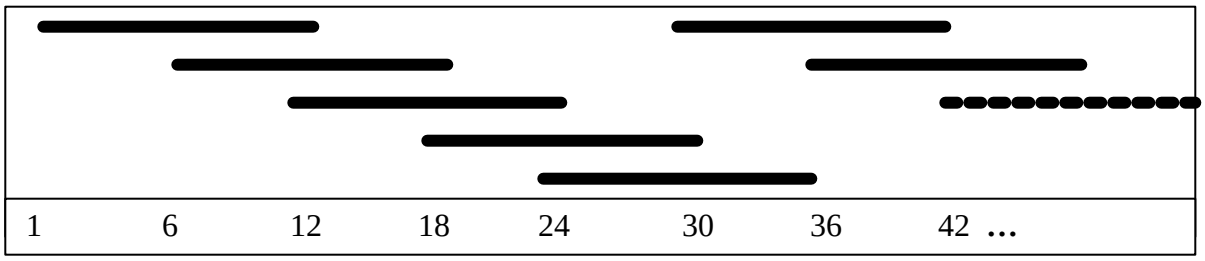
Air Conditoner Switches

Pepco began its full-scale air conditioner switch program over fifteen years ago, following an experimental period to determine statistical load reduction values and technology requirements. Commercially available radio switches are installed in the compressor control circuitry for the air conditioner. When the switch recognizes its coded message, it immediately operates and prevents the compressor from running for a random time – that is, it is in the "off" position. The time period is centered at seven minutes with most timers expiring within plus or minus one minute of that. The central controller program retransmits the signal to a set of switches to maintain a selected period of "off" times. The cycle chosen by Pepco is 13 minutes "off" and 17 minutes "on" in each half hour period. The complete installation of switches is divided into several (currently, 5) groups that are staggered in their initial operation period so that at any given period of time, approximately one-third of controlled air conditioners will be "off." There is a subset of customers who accept a 100% "off" program (for a higher payment) which enhances the load reduction of the entire program. The technology employed for the radio controlled switches is quite mature, and switches with greater capabilities are available today.

Much of the capability of the program resides in the central controller (and the statistical distribution of air conditioner groups). The central controller generates the timing signals for groups of cycled air conditioners and forwards that information to the radio transmitter system. The radio transmitter system uses FM paging band signals, and is based on transmitters located around the distribution service territory. The central controller starts a curtailment immediately upon operator selection by generating the signals for the group next in the queue, leftover from the previous operation of a curtailment. Signals are generated for that group for six minutes, and the switch timer maintains the "off" condition for another seven for a total of thirteen minutes.

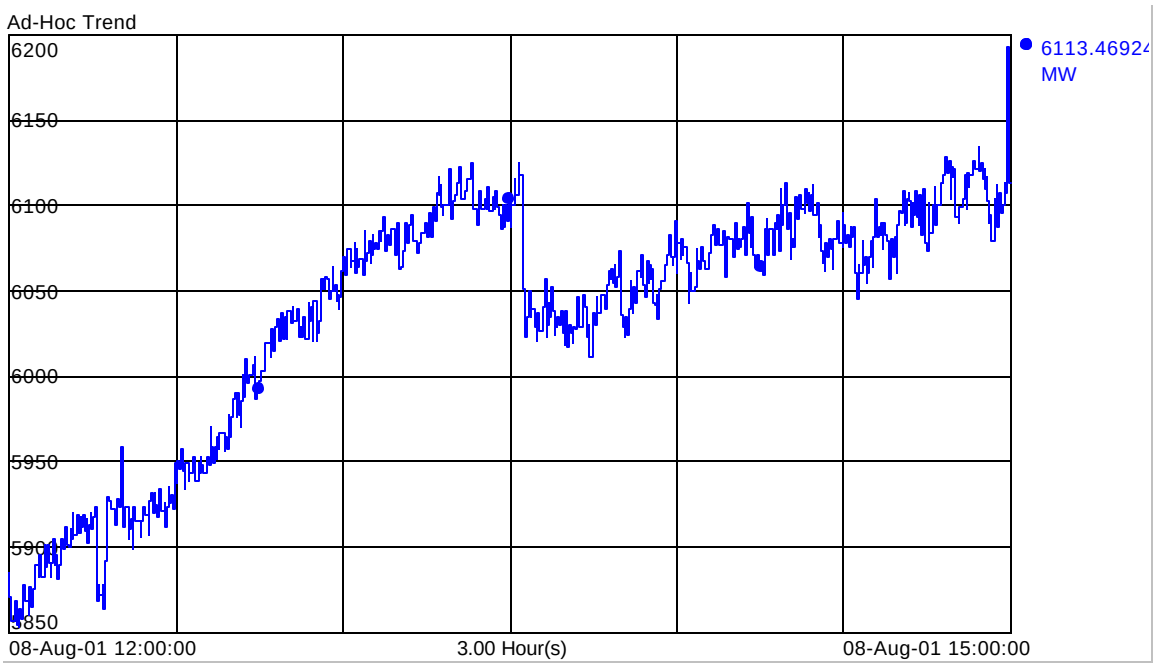
The controller initiates a new group every six minutes so that, except for the statistical overlap, two groups are "off" at all times during the curtailment. See Figure 1 for the cycle pattern.

Figure 1 – Cycle Pattern



Pepco's total number of switches is approximately 170,000, for a 20 percent penetration, most of which are cycling switches on air conditioners. A smaller number not cycled are on water heaters (which show little reduction during summer day periods) and the 100% "off" air conditioners. The system is designed to reduce peak load on summer days and is not useful outside that period. When operated, it exhibits almost immediate load reduction, as shown in Figure 2. The curtailment was scheduled to start at 1:30 PM – the chart is slightly offset, and the actual time the reduction started was 1:30:45 PM. The reduction is approximately 160 MW on a gross system load of 6100 MW.

Figure 2 – Load Reduction on 08-AUG-01



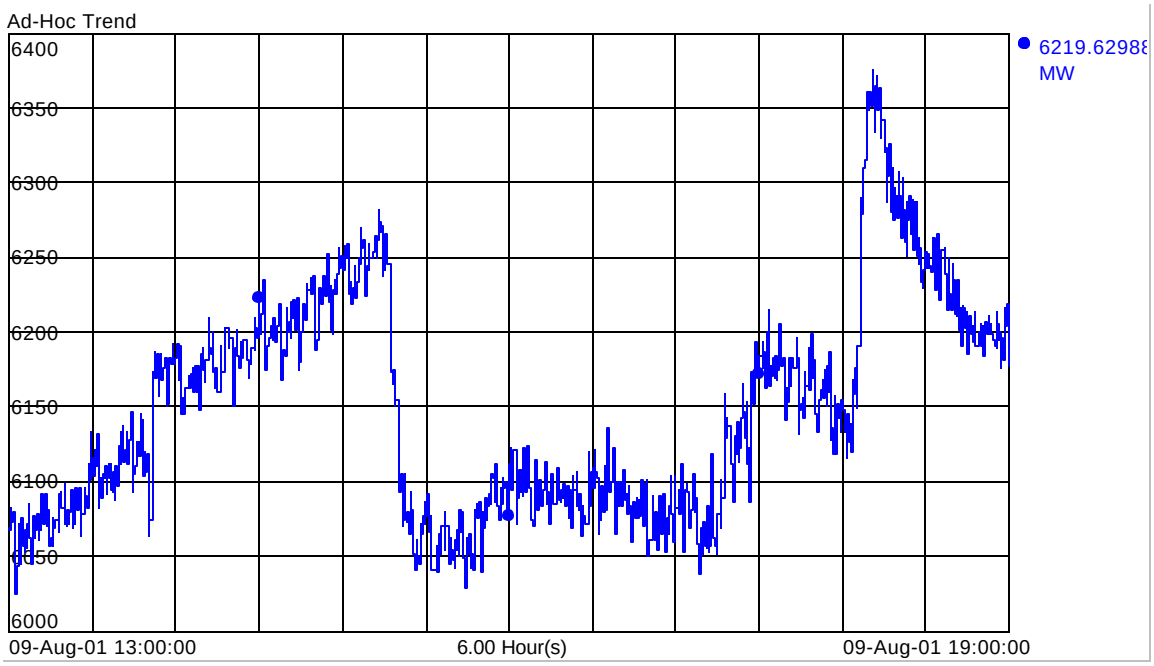
The very abrupt reduction is a result of coordinated curtailment of two groups to immediately obtain the full reduction potential. Charts for other days show a more gradual reduction in load.

Voltage Reduction

The air conditioner control program can be considered both an emergency and economic peak reduction program. Pepco also has the capability to rapidly reduce distribution system voltage, and that is considered strictly to be an emergency program. The capability to reduce distribution system voltage quickly and in a coordinated manner is a result of system design criteria for normal voltage control. Pepco's distribution substation transformers are equipped for tap-changing-under-load (TCUL) and are normally controlled by a central EMS program to maintain a set voltage for each substation as load varies. That program normally operates on a 15 minute cycle, but can be manually initiated. The desired voltage for all substations can also be scaled for all substations at one time. That is, the operator can select a 5% system-wide voltage reduction, and each substation will reduce voltage by 5% from its normal controlled voltage. At the same time, the EMS will send "freeze" commands (via the same type of radio switches used for the air conditioner control system) to distribution line switched capacitors and voltage regulators so that line equipment will not negate the substation voltage reduction. The result is a very quick and complete distribution level voltage reduction and resultant load reduction.

Voltage reduction is one of the lowest priority emergency steps for a capacity deficiency, so it is rarely used, but it was used on August 9, 2001. The results are shown in Figure 3. The reduction is approximately 200 MW on a gross system load of 6250 MW.

Figure 3 – Results of Voltage Reduction, 09-AUG-01



The chart also shows the effects of ending the voltage reduction and the air conditioner load reduction at the same time. The return to normal voltage and the ending of the forced air conditioner diversity created load greater than experienced when the programs were initiated. Fortunately, system capacity was sufficient to handle the load level.

Pepco's air conditioner load reduction program and its substation voltage reduction capability have shown their value as both economic and reliability enhancement tools.

Author information

Richard J. Kafka, P.E. received the B.S. degree in physics from Regis College, Denver, CO, in 1970 and M.S. degree from Purdue University, West Lafayette, IN, in 1972. He has been employed by the Potomac Electric Power Company since 1973. He was assigned to Pepco's system restoration study team in 1979, which produced one of the first formal power flow studies for a system restoration plan. He has continued to be active in the area of power system restoration studies and events. He was on the working group that developed the PJM Operating Agreement that was finally approved by the FERC in November, 1997. The Operating Agreement governs the PJM energy market. Mr. Kafka is Principal Engineer, Transmission of Pepco, a Fellow of the IEEE, a charter member of the IEEE Power System Restoration Working Group, Chair of the IEEE PES Operations Subcommittee, and a Registered Professional Engineer in the State of Maryland.